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BULLETIN

OF THE

AMERICAN PHYSICAL SOCIETY

PROGRAM OF THE

TORONTO MEETING

AT

THE UNIVERSITY OF TORONTO

TORONTO, CANADA

JUNE 24 AND 25, 1938

PUBLISHED BY THE AMERICAN PHYSICAL SOCIETY
SEVEN ISSUES EACH YEAR

The American Physical Society

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BULLETIN

of the

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JUNE 9, 1938 Vol. 13, No. 4

BULLETIN

OF THE

AMERICAN PHYSICAL SOCIETY

TORONTO MEETING, JUNE 24–25, 1938

(*Eastern Daylight Saving Time*)

JOINT MEETING WITH THE AMERICAN PHYSICS TEACHERS ASSOCIATION

THE 222nd regular meeting of the American Physical Society will be held at the University of Toronto, Toronto, Canada on Friday and Saturday, June 24–25, 1938 as a joint meeting with the American Association of Physics Teachers. All scientific sessions will be held in the McLennan Laboratory, Department of Physics, University of Toronto. The first session will be at 9:30 o'clock, Friday morning, June 24, Eastern Daylight Saving Time.

Symposium. On Saturday morning, June 25 at 9:30 o'clock, in the Main Lecture Room of McLennan Laboratory there will be a symposium of invited papers. Professor H. A. McTaggart of the University of Toronto will speak on *Monomolecular Films;* Professor J. W. Beams of the University of Virginia will speak on *High Speed Centrifuges and Some of Their Applications;* Professor H. Grayson Smith of the University of Toronto will speak on *Superconductivity;* and Professor H. Kramers of Leiden, Holland will speak on *Magnetic Phenomena at Low Temperatures.*

Joint Meeting with A. A. P. T. On Friday morning at 9:30 o'clock in Room 43 of the McLennan Laboratory there will be a joint meeting of both societies at which the Honorable Dr. H. J. Cody, president of the University of Toronto, will give a short address of welcome. This will be followed by an address by Dr. John Satterly of the University of Toronto on *A Comparison of the Teaching of Physics in England and America.* A demonstration of a few unique lecture experiments will follow in the same lecture room. Also the department of physics has arranged for a display of physical experiments, useful for teaching purposes, in one of the large laboratories. One or two of the undergraduate laboratories will also be open for inspection. At about 12 o'clock it is hoped to have liquid helium prepared so that everyone may have an opportunity to see liquid helium in its two states, helium I and helium II.

Registration. Registration (50¢ per family) will open on the afternoon of Thursday, June 23rd at 2:00 o'clock in the McLennan Laboratory. Booklets containing tickets for rooms, meals, the official dinner, as well as the complimentary garden party and excursions, will be available at the time of registration. The cost of these booklets will be the net amount for those services of which each individual chooses to take advantage.

Accommodations. Insofar as possible visiting members of the Society and their friends, including ladies, will be housed in the Student Residences. There are in the University of Toronto Residences about 225 rooms for men or women and some 50 double rooms available for married couples. The rooms will be opened on Thursday afternoon, June 23 and may be occupied until Monday morning. The charge will be $2.00 per person for the first night and $1.25 per person for each succeeding night. *Reservations should be made at once on the enclosed form.* The local committee has arranged to have breakfast and luncheon served at Hart House on Friday

and Saturday at a cost of 50¢ per meal. In addition there are several first-class restaurants convenient to the university campus.

Those who prefer hotel accommodations should make reservations by writing directly to the hotel. Minimum rates are shown for single and double rooms with bath, for a selected list of hotels convenient to the University.

	single	double
Royal York Hotel	$4.00	$6.00
King Edward Hotel	$3.00	$5.00
Waverley Hotel	$2.50	$4.00
Alexandra Palace Hotel	$2.50	$4.00
Park Plaza Hotel	$3.50	$5.50
Windsor Arms Hotel	$2.50	$3.50

Dinner. On Friday evening at 7:00 o'clock there will be a joint dinner for the members of the two societies and their friends at Hart House on the university campus. This dinner will be informal; the price will be $1.50 per person.

Entertainment. The President of the University of Toronto is inviting all members of the two societies and their wives and friends to a garden party on the lawn of the Royal Ontario Museum, at 4:30 o'clock on Friday, June 24.

Various visits are being arranged for Saturday afternoon. These will include a visit to the David Dunlap Observatory of the University of Toronto at Richmond Hill about ten miles north of the city; a visit to the new Airport now being developed in connection with the harbor of Toronto. Officers of the Toronto Harbor Commission will provide boat transportation to the new Airport site, and will conduct the party; and a visit to the new Trans-Canada Airport being developed in cooperation with Toronto at Malton, situated about 15 miles northwest of the city. Officers of the commission in charge will conduct the party at the site.

Any visitor will be able to avail himself of only one of these excursions, and as the numbers for each excursion will be limited each person will be asked to express his choice at the time he registers. It is intended to supply transportation for those who have not their own cars.

Members may obtain information upon registration as to special arrangements for golf, swimming, boat trips, and motor tours.

For those who will find it convenient to arrive on Thursday attention may be drawn to the weekly summer symphony concert given on Thursday evenings in the University Arena. These concerts are at popular prices.

Demonstrations. On Friday morning liquid helium will be made and displayed in the cryogenic section of the laboratory at a time to be announced at the morning session.

The teachers of physics in the secondary schools in and around Toronto are collaborating with the staff of the department of physics in arranging a display of striking physics experiments which will be open for inspection during the whole meeting in Room 10 of the laboratory.

Vacation Facilities. Ontario offers a wide variety of vacation facilities for those who may wish to avail themselves of them. Information concerning various fishing and summer resorts will be sent to those who desire it.

American Association for the Advancement of Science. There will be a special physics program at the Ottawa Meeting of the A. A. A. S. on Monday and Tuesday, June 27 and 28, 1938. The papers to be presented include one on "The Unsymmetrical Doppler Effect in Hydrogen Canal Rays and its Significance in Optical Theories" by Herbert E. Ives and another on "Ultrasonics—Marine Applications" by R. W. Boyle. There will also be a group of papers on radioactive rays and other topics contributed by physicists associated with the National Research Council of Canada, Queen's University and several other institutions. Those desiring to go from the Toronto meeting will have Sunday to make the trip. Details of motor routes from Toronto to Ottawa, 275 miles, will be available at the registration desk. Details of the meeting will be printed in *Science*.

Summer Meeting at San Diego. The summer meeting on the Pacific Coast will be held in affiliation with the American Association for the Advancement of Science at San Diego, California, June 22–24, 1938.

General Rules Relating to Papers

Only those titles of papers shall be listed on the preliminary program of a meeting of the Society for which abstracts ready for publication are in the hands of the Secretary.

On December 28, 1936, the Society voted that:

No papers may be accepted for presentation at any meeting of the Society subsequent to the closing date stated in the printed call for that meeting.

When two or more papers are offered by the same member, one only of these will be assigned a place on the regular program, while the others will be placed in a supplementary program. (A paper presented by two or more authors is assigned to the first named author.)

All supplementary papers will be grouped according to subject matter and will be called for at their appropriate sessions only, these sessions to be designated on the program. The presiding officer may assign a reduced time to these papers or may in his discretion call for them to be read by title only.

Except by special vote of the Society, the maximum allowance of time for the presentation of a paper shall be ten minutes. The presiding officer shall enforce this rule.

Titles and abstracts of the papers to be presented are given in the following pages. These abstracts have not been corrected by the authors. After correction the abstracts will be published in an early number of the *Physical Review*. Authors should send corrections to the Publications Manager, The American Institute of Physics Incorporated, 175 Fifth Avenue, New York, N. Y.

Other meetings for the current season are as follows:

221. June 22–24, 1938. San Diego, California.
223. November 25–26, 1938. Chicago, Illinois.
224. December, 1938. Los Angeles, California.
225. December 27–29, 1938. Annual Meeting. Washington, D. C.
226. February 24–25, 1939. New York, N. Y.

W. L. Severinghaus, *Secretary*
Columbia University, New York, N. Y.
June 9, 1938.

ADVANCE REGISTRATION CARD

American Physical Society

Toronto Meeting, June 24–25, 1938

Please return this card at once if you expect to attend the meeting.

Name..... (Last name / First name / Other initials)

I plan to go to Toronto by { automobile ☐ / train ☐ }

arriving about { Thursday A.M. / P.M. / Friday A.M. / P.M. } leaving about { Saturday A.M. / P.M. / Sunday A.M. / P.M. }

Please reserve rooms in the dormitory as follows:

☐ single room for man: ☐ single room for woman

☐ room for man and wife

☐ Please reserve.....tickets for dinner @ $1.50.

Return this card to:

Professor J. O. Wilhelm, Department of Physics, University of Toronto, Toronto, Canada.

CALENDAR

(*Eastern Daylight Saving Time*)

Friday Morning, June 24

9:30 o'clock: McLennan Laboratory: Room 43: Joint Meeting with A. A. P. T.: Talks by the Honorable Dr. H. J. Cody, President of the University of Toronto, and Dr. John Satterly of the University of Toronto.

10:45 o'clock: McLennan Laboratory: Demonstrations.

11:00 o'clock: McLennan Laboratory: Meeting of the Council.

Friday Afternoon, June 24

2:00 o'clock: McLennan Laboratory: Room 43: Physical Society papers 1–22. See pages 7–11.

4:00 o'clock: Royal Ontario Museum: Garden Party of the President of the University of Toronto.

Friday Evening, June 24

7:00 o'clock: Hart House: Joint dinner of the two societies.

Saturday Morning, June 25

9:30 o'clock: McLennan Laboratory: Room 43: Symposium of invited papers: speakers: Professor H. A. McTaggart, Professor J. W. Beams, Professor H. Grayson Smith and Professor H. A. Kramers.

2:00 o'clock: Excursions.

Correction to the Bulletin of the American Physical Society, San Diego Meeting

"Sessions at the San Diego Meeting will be held in quarters in Balboa Park and not at the San Diego State College as announced on the cover of the Bulletin of the 221st meeting."

PROGRAM

Friday Morning at 9:30 o'clock

McLennan Laboratory, Room 43

Joint Meeting with the American Association of Physics Teachers

1. **Short Address of Welcome** from the President of the University of Toronto, the Hon. Dr. H. J. Cody.
2. **A Comparison of the Teaching of Physics in England and America.** Professor John Satterly, *University of Toronto.*
3. **Demonstration of Experiments.** Professor E. F. Burton and Members of the Staff in Physics, *University of Toronto*, and Teachers of Physics in Secondary Schools of the Toronto Area.
4. **Liquid Helium Produced and Exhibited.** Cryogenic Laboratory, University of Toronto. Professor E. F. Burton.

Friday Afternoon at 2:00 o'clock

McLennan Laboratory, Room 43

Papers Nos. 1, 7, 9 and 16 will be read by title.

1. Spectrochemical Analysis of Fertilizers, Particularly for the Micrometabolic Elements. Stanley S. Ballard, *University of Hawaii.**—Samples of twelve basic commercial fertilizers have been analyzed by the spectrochemical methods developed in the spectroscopic laboratory of the Experiment Station of the Hawaiian Sugar Planters' Association.[1] Analyses were performed semi-quantitatively, the amount of each element present in a sample being indicated by one of the following designations: *Lots, Some, Less, Trace, Not Detected.* Such an analysis reveals the presence or absence in a sample of the fifty-odd arc sensitive elements, of which twenty-one were encountered in the present investigation. The various fertilizers were found to differ greatly in the number of mineral elements present. Particular attention was given to the minor plant nutrients, the micrometabolic or so-called "less essential" elements iron, manganese, boron, copper, zinc and aluminum, as well as to the major elements phosphorus, potassium, calcium and magnesium which often occurred as impurities when they were not present as major constituents. The fertilizers tested included two sulfates of ammonia, two nitrates of soda, two nitrates of potash, muriate of potash, two raw rock phosphates, two superphosphates, and phosphate of ammonia. The last five named proved to be the best sources of the minor elements. This paper will appear in full in *The Hawaiian Planters' Record.*

* To be read by title.
[1] S. S. Ballard, Phys. Rev. **52**, 253A (1937).

2. The Effects of Pressure and Temperature on the Viscosity of Monosubstituted Toluenes. H. E. Morgan and R. B. Dow, *Pennsylvania State College.*—The viscosity of *ortho-*, *meta-*, and *para-* forms of chloro-, bromo-, nitro- and iodotoluene was determined at 30°, 75°, and 99°C at pressures ranging from atmospheric to 4000 kg/cm² by means of the rolling-ball type of high pressure viscometer. Calibration of the viscometer enabled the absolute viscosity to be computed at the three temperatures of the experimental range of pressure. The applicability and validity of the log coeff. of viscosity-pressure relation to represent the data are discussed. The tendency of the pressure coefficient both to increase and decrease as the substituted group is moved in the series, leads to the conclusion that no general rule can be stated for the effect of change of position of the substituted group. A plot of the pressure coefficient against atomic weight (M.W. for NO_2) shows that while the former tends to increase with the latter for the *ortho-* and *meta-* bindings, it clearly decreases for the *para-* binding. Increase of temperature reduces these differences. It is suggested that this anomaly may be due to a fundamental difference in the vibration of the toluene ring when the substituted group is attached in the para position, a result which would be expected to influence the type of "interlocking" at high pressures as pictured by Bridgman.

3. Viscosity Characteristics of Lubricating Oils at High Pressure at Various Temperatures. R. B. Dow, *The Pennsylvania State College.*—The study of the physical properties of oils at high pressures begun at Harvard University and being continued at the School of Chemistry and Physics, The Pennsylvania State College, is reviewed briefly. The pressure coefficient of viscosity at 100°, 130°, and 210°F and its relation to composition, molecular weight, and viscosity index is discussed for data obtained in this laboratory on Pennsylvania, Oklahoma, and California blends, and

solvent extracted oils. Similar analysis is given for interpolated data from other laboratories for lard and castor oil. Comparison of a rolling ball viscometer with an absolute, concentric cylinder type shows that both instruments are capable of good accuracy and satisfactory precision at various pressures and temperatures. No evidence of a semi-colloidal or non-Newtonian behavior, as observed by the independence of the coefficient of viscosity and the rate of shear, has been observed for these oils at the pressures and temperatures investigated.

4. New Survey of the Spectrum of the International Iron Arc in the Range 10,000 to 2000A. DOROTHY W. WEEKS, *Wilson College*, AND GEORGE R. HARRISON, *Massachusetts Institute of Technology*.—Wave-length measurements have been made on some 10,000 lines obtained in the international iron arc. A 10-meter concave grating having 30,000 lines per inch was used in Paschen mounting at dispersion 0.4A/mm for the range 2000 to 6900A. For 6900 to 10,000A, a 10-meter grating having 15,000 lines per inch was used in a Wadsworth mounting at dispersion 3.3A/mm. Two hundred twenty inch plates were measured on a computing-recording comparator, the resulting wave-lengths being self-consistent to 0.003A or better as determined by repeat runs and by the combination principle. After elimination of all impurity lines and possible ghosts the number of known iron lines is approximately trebled. The able assistance of W.P.A. clerical help is gratefully acknowledged.

5. Electric Arc Reignition at High Pressures. J. D. COBINE, R. B. POWER* AND L. P. WINSOR, *Harvard Graduate School of Engineering*.—A study has been made of the reignition of short a.c. arcs in air at pressures from one to eight atmospheres, for currents under 3.5 amperes, in a resistance circuit. Pure graphite electrodes were used and were separated by distances from 1/8 mm to 3 mm. As previously indicated for nitrogen, the reignition voltage under these conditions increases with pressure when the r.m.s. arc current is kept constant. The reignition potential for constant gas pressure decreases as the current is increased. The characteristic of reignition potential vs. current has been found to exhibit a discontinuity at a critical current. For this current the reignition potential decreases by about 1000 volts to a new characteristic typical of the higher currents. This critical current depends upon the gas pressure and to a lesser degree upon the electrode separation. For pressures of atmospheric, or below, the transition is not abrupt but is completely defined. As the r.m.s. current is increased from low values to values near the critical value, the number of cycles for which the reignition potential is on the higher characteristic decreases. For currents equal to, or greater than the critical value, only the low reignition potentials are obtained. This transition is accompanied by a change in the burning voltage of the arc. The factors influencing reignition are discussed and possible mechanisms are considered.

* Kennecott Wire and Cable Company.

6. Townsend Ionization Coefficients in Argon Photo-Tubes. W. S. HUXFORD, *Northwestern University*.—Values of the ionization coefficient α have been obtained in Cs-Ag-O tubes with parallel plates in which the cathodes were activated by the usual commercial process. Six tubes having electrode separations of 2, 4, 6, 8, 12 and 16 mm were employed containing argon at a pressure of 0.175 mm of mercury. The P.D. values lie in the neighborhood of the minimum sparking potential and the measurements cover a range which includes the maximum value of α/E plotted as a function of E/p. The results are in substantial agreement with other recent measurements of the electron ionization coefficient in highly purified argon. Calculations of the coefficient γ, which represents the number of electrons leaving the cathode for each positive ion reaching it, yield values which are considerably greater than those obtained with cathodes having a higher electron work function. In this calculation account must be taken of an increased photo-sensitivity of the cathode which occurs at high gas amplification and is apparently induced by the action of positive ions. Sparking potential measurements for pure argon in tubes having nickel cathodes, nickel cathodes activated with barium, and Cs-Ag-O cathodes show a progressive lowering of the minimum sparking potential and a shift of this minimum to lower P.D. values as the work function of the cathode decreases.

7. Ultrasonic Reflection Losses in Air, Helium and CO_2.* R. S. ALLEMAN AND J. C. HUBBARD, *Johns Hopkins University*.—The new heat conduction theory of acoustic reflection developed by Herzfeld[1] requires a modification of the theory of the acoustic resonator interferometer.[2] As a result the values of γ^2, the intensity reflection coefficient, first obtained by Hubbard,[2] and those of Curtis,[3] showing a dependence upon frequency, have been recalculated, and together with new values by the authors are given below, showing excellent general agreement with Herzfeld's theory.

Author	Gas	kc/sec.	$1-\gamma^2$ Exp.	Theo.
1. H	Air	597	0.034	0.034
2. A	"	1237	.051	.049
3. C	CO_2	189	.015	.0122
4. H	"	597	.0148	.0216
5. C	He	252	.048	.046
6. A	"	792	.089	.081
7. C	"	1001	.085	.092
8. A	"	1192	.101	.097
9. A	"	1976	.118	.124

* To be read by title.
[1] K. F. Herzfeld, Phys. Rev. **53**, 899 (1938).
[2] J. C. Hubbard, Phys. Rev. **38**, 1011 (1931); **41**, 523 (1932); **46**, 525 (1934).
[3] R. W. Curtis, Phys. Rev. **46**, 811 (1934).

8. An X-Ray Test of Superstructure in $FeNi_3$. F. E. HAWORTH, *Bell Telephone Laboratories, Inc.*—A search has been made for superstructure in permalloy of composition near $FeNi_3$. Curves of x-ray scattering power near the absorption edges of Ni and Fe show that Fe$K\beta$ radiation should give the strongest superstructure lines, and calculations indicate that reflection from (321) planes of a perfectly ordered structure should have about one-seventh the intensity of the ordinary (222) reflection. The specimen was a powdered alloy containing 70 percent nickel, annealed at 1000°C and baked at 425°C. It was placed in a focusing camera in a beam of Fe$K\beta$ rays which were selected and

concentrated by a curved rocksalt crystal, and exposed for one hundred hours. No superstructure lines appeared, although superstructure in β-brass was easily detected with similar technique. The negative result indicates that no long range order exists in the region near $FeNi_3$.

9. The Spectrum of Doubly Ionized Lead, Pb III.* M. F. CRAWFORD, A. B. MCLAY AND A. M. CROOKER, *University of Toronto.*—The spectrum of lead has been measured in the region 800A to 10,000A. The lines were excited by an electrodeless discharge in lead vapor. A series of spectrograms of the entire region were taken for different excitation conditions in the source, and the variation of intensity of a line with excitation showed, in general, to which spectrum it belonged. About four hundred lines have been classified as transitions between ninety levels of the following configurations: $6sns$, $n=6$ to 10; $6snp$, $n=6$ to 8; $6snd$, $n=6$ to 9; $6snf$, $n=5$ and 6; $6sng$, $n=5$ to 8; $6snh$, $n=6$ to 9; $6p^2$; $6p\ 7s$; $6p\ 6d$; $5d^9\ 6s^2\ 6p$. The hyperfine structures of sixty-four of the classified lines have been measured with a twenty-one foot grating by Crooker.[1] The observed structures of these are consistent with this multiplet analysis. The $6sng$ configurations show interesting anomalous multiplet and hyperfine structures. A theoretical interpretation of these will be published soon by one of the authors (M. F. C.).

* To be read by title.
[1] Can. J. Research **14**, 115 (1936).

10. The Number of Lines in a Series as a Function of Electron Concentration. FRED L. MOHLER, *National Bureau of Standards.*—In the spectrum of an intense discharge the successive lines of a series are increasingly broadened until they merge into a continuous spectrum at an effective quantum number which can be quite definitely evaluated. Spectra of capillary discharges under conditions of nearly complete ionization have been obtained with electron concentrations, N_e, ranging from 5×10^{13} to 1.3×10^{16}. In this range the maximum effective quantum number n for the violet component of the diffuse series decreases from 17.0 to 8.0. Values are about 0.3 greater for the red component and 0.5 greater for the F series. A plot of $\log n$ *versus* $\log N_e$ gives a straight line with a slope indicating that $n^{-7.6}$ is proportional to N_e. Spectra of low current discharges give n about 25 for $N_e=10^{12}$ but values seem to depend on vapor pressure and resolving power for N_e less than 10^{13}. Sugita has shown that if the number of states is limited by electron collisions then n^{-7} is proportional to N_e. On the view that n determines the number of discrete states it follows that the ionization potential is reduced by about 0.2 volt when $N_e=10^{16}$.

11. The Effect of Magnetic Fields on Persistent Currents in a Closed Superconducting Circuit. K. C. MANN, H. GRAYSON SMITH AND J. O. WILHELM, *University of Toronto.*—A study has been made of the effect of external magnetic fields in preventing persistent currents from flowing in a closed superconducting circuit, in order to determine as closely as possible the field strength at which the first traces of electrical resistance appear. In agreement with earlier work by a less accurate method,[1] and with the resistance measurements of de Haas,[2] but in contradiction to the idealized theory of the transition state,[3] it is clearly shown that no resistance appears until the mean magnetic induction within the specimen becomes considerable. It has been found further that the amount of resistanceless current which the specimen can carry under these conditions is limited. The results are greatly affected by the addition of small amounts of impurity. When the current strength was slightly greater than its equilibrium value, it required a measurable time to decay, the behavior being similar to the relaxation effects observed in the magnetic and thermal properties of superconductors. Several authors have suggested that the relaxation in magnetic properties is due to the decay of eddy currents. A thermodynamic argument now shows that relaxation in the thermal properties will be caused in the same way.

[1] K. C. Mann and J. O. Wilhelm, Trans. Roy. Soc. Canada **31**, 19 (1937).
[2] W. J. de Haas, J. Voogt and J. M. Jonker, Physica **1**, 281 (1934).
[3] F. London, Physica **3**, 450 (1936); Nature **137**, 991 (1936).

12. A Theoretical Lower Bound for the Energy of the Normal State of Helium. A. F. STEVENSON AND M. F. CRAWFORD, *University of Toronto.*—A method of using Weinstein's expression[1] for a lower bound for the energy, as given recently by one of us,[2] has been applied to the normal state of helium, using the same sequence of functions as was used by Hylleraas in his calculation of an upper bound. The successive approximations obtained by the lower bound method show a satisfactory convergence towards the upper bound finally obtained by Hylleraas.

[1] D. H. Weinstein, Proc. Nat. Acad. Sci. **20**, 529 (1934).
[2] A. F. Stevenson, Phys. Rev. **53**, 199 (1938).

13. Experiments and Theory on the Performance of the Geiger Point Counter. J. LLOYD BOHN AND JOSEPH MORGAN, *Temple University.*—Preparation of sensitive and insensitive points, why rough points or very sharp ones will not work properly, and why a point and plane combination may cease to function as the point approaches the plane will be discussed. Curves showing operating characteristics of various combinations of points, planes and tubes at atmospheric pressure and for point and tube combination at various pressures will be shown—also curves showing the variation in time for the reappearance of counts, after a Bakelite cap on the front of the tube had been touched, with voltage. That a modified form of Zeleny's[1] theory suffices to explain the action of the Geiger point counter is concluded.

[1] Phys. Rev. **15**, 566 (1922).

14. A Vacuum Tube High Voltage Stabilizing Circuit for d.c. Sources. H. L. SCHULTZ,* *Yale University.*—When the stabilizing circuit to be described is applied to a conventional rectified-filtered source, initial voltage variations are reduced to less than 0.03 percent and the apparent internal resistance viewed from the output is of the order of a few thousandths of an ohm. Continuous control of output voltage from several hundred to several thousand volts at currents as high as several hundred milliamperes is

possible using tubes of the receiving type. The circuit is similar to one developed by C. D. Bock, formerly of this laboratory, and has the following principle of operation. A triode or group of triodes connected in parallel is employed as a variable impedance in the positive line from the source to be stabilized. Residual voltage variations across part of a bleeder resistance in the output are amplified and actuate the grid of the control tube or tubes in proper phase with respect to the incoming variations. Simplicity and an actual improvement in operation is attained when plate and screen voltages for this amplifier are derived from taps on the common bleeder resistance. Instability occurs only if the load has appreciable reactance.

* Sterling Fellow.

15. Threshold Energies for Some (p,n) Reactions. M. G. WHITE, L. A. DELSASSO, RUBBY SHERR AND L. N. RIDENOUR, *Princeton University.*—Measurements of yield as a function of energy have been made by the method of stacked foils for several nuclear reactions of the (p,n) type. The maximum incident proton energy is 4.2 Mev; the ion currents employed are about 1 microampere. The results to date indicate that the energy thresholds of three reactions studied are as follows:

Reaction	Half-life of Radioelement	Threshold energy, Mev
$Ni^{60}(p,\gamma)Cu^{61}$ or $Ni^{61}(p,n)Cu^{61}$	3.4 hours	<1.9
$Ni^{64}(p,n)Cu^{64}$	12.8 hours	2.1
$Ag^{?}(p,n)Cd^{?}$	6.7 hours	2.4

16. The Dirac Equation with Spin Greater Than 1/2.* ARTHUR BRAMLEY, *Washington, D. C.*—The interesting feature of the equations for electron with spin greater than 1/2 and rest mass different from zero is that besides the Hamiltonian there exist linear equations of constraint acting on the wave functions.[1] Their invariance under reflection demands that the two numbers l and k characterizing the spin be identical. From these two sets of four linear equations second order differential equations can be constructed. In order to make the spin components definite we shall take the electron as propagated in the direction of a constant magnetic field. The second order equation corresponding to the relativistic Pauli equation[2] shows that the magnetic interaction is proportional to the velocity vector, not, as we might expect, the spin vector. Another consequence of the equations is that the matrices α must be expressed in terms of hypercomplex numbers such that $\alpha_x^2=\alpha_y^2=\alpha_z^2=k(k+1)/3$. In that case it follows from the equations of constraint that

$$\left(\frac{pz}{pl}\right)^2=\frac{(3+R)k+R}{(3R+1)k+1} \quad \text{where} \quad R=-\left|\frac{u'v'+u^2v^2}{u'v'-u^2v^2}\right|^2$$

in Dirac's notation. This extra condition among the components of the momentum requires that for every velocity there shall be a characteristic rest mass.[3]

* To be read by title.
[1] Dirac, Proc. Roy. Soc. **155**, 447 (1936).
[2] Sakata and Yukawa, Japan Proc. Phys. Math. Soc. **19**, 91 (1937).
[3] Bramley, Science **87**, 281 (1938).

17. Virtual Levels of Be^5 and the Alpha-Particle Model. JENNY E. ROSENTHAL, *Brooklyn College.*—It is known experimentally that the normal state of Be^8 is barely stable and that there is a broad virtual level at about 3 Mev. A theoretical calculation has been made assuming a "molecular" model with a Morse potential between the α-particles adjusted to a 10 Mev depth of the potential well. The wave functions ψ were evaluated for the continuum region; only the order of magnitude of the moment of inertia and not its exact value is important in this calculation. Theoretically we can speak of a virtual state if, for a given value of the angular momentum, the ratio of the amplitude of ψ inside the potential well to that outside reaches an appreciable maximum for some energy range. The calculations show that no maximum exists for any value of the energy; a consideration of the Coulomb barrier should not modify the results appreciably. We conclude that the molecular model does not account for the existence of virtual levels.

18. The β-Ray Spectrum of I^{128}. R. H. BACON, E. N. GRISEWOOD AND C. W. VAN DER MERWE, *New York University, Washington Square College.*—The β-ray spectrum of I^{128} has been measured in a Wilson cloud chamber. A K.U. plot shows two branches with end points at 2.1 Mev and 1.2 Mev, respectively. The end point of the high energy group agrees with that found by Alichanian, Alichanow and Dzelepow,* but the literature, to our knowledge, makes no mention of the other group. Details of the method used will be given at the meeting.

* Physik. Zeits. Sowjetunion **10**, 78–102 (1936).

19. The Radioactive Isotope of Samarium. T. R. WILKINS, *University of Rochester* AND A. J. DEMPSTER, *University of Chicago.*—G. Hevesy (1934) reported that samarium was a natural α-emitter with an *apparent* half-life of 1.2×10^{12} years. The *real* half-life can be calculated only if the active isotope can be identified and its percentage abundance known. Various suggestions have been made as to this isotope, some based on hyperfine structure abnormalities and some on relations between decay constant, nuclear radius and abundance ratios. We have devised a new tool for such studies by combining the mass spectrograph and the photographic emulsion track technique.* A direct deposit of the isotopes of samarium was made on an Ilford R type emulsion in the mass spectrograph. The plate was set aside for several months and then developed and examined by the microscope. These tracks lie in the emulsion, and are seen by focusing on the emulsion through the half-samariumed deposit. The typical (1.13 cm air range and α-ray spacing) track under the spectrum line of Sm^{148} has been found. Schumann plates have been used for calibration but these are actually unnecessary since the numbers of "spots" comprising the spectrum lines correspond to the abundance ratios of the isotopes. Taking the abundance of Sm^{148} as 14 percent, the *real* half-life will be 14 percent of the *apparent* half-life.

* T. R. Wilkins and H. J. St. Helens, Phys. Rev. **51**, 1026 (1937).

20. Altitude Variation of the Relative Frequency of Occurrence of Pairs and Larger Cosmic-Ray Showers. DAROL K. FROMAN, *Macdonald College, McGill University* AND J. C. STEARNS, *University of Denver.*—The ratio of triple to quadruple frequency of coincidence of Geiger-Müller counters, arranged to detect showers containing two or more and three or more ionizing shower rays, respectively, has been measured for various thicknesses of scatterer at two altitudes, *viz.* 36 meters and 4300 meters above sea level. In accordance with the predictions of the multiplicative theory of shower production, this ratio decreases rapidly with increase in the thickness of the scatterer. For very thin scatterers, the ratio is much greater at the higher altitude. For very thin scatterers it is expected, on the theory, that this ratio would be greater for showers produced by photons than it would for electron-induced showers. Experimental data on this point are being taken, and the preliminary results tend to confirm this view. The marked variation of the ratio with altitude suggests the possibility that the relative number of photons and electrons in the cosmic-ray complex is a function of altitude. Experiments, designed to test this point, are being initiated this summer.

21. The Michelson-Morley-Miller Experiment. W. B. CARTMEL, *Université de Montréal.*—According to Lorentz $t=lv^2/c^3\cdot(1+\cos^2-\theta)$. In an oblique interferometer we have $\cos^2\theta$ in one arm and $\sin^2(\theta-\Omega)$ in the other and for their difference,

$$t=lv^2/c^3[\cos 2\theta-\sin\Omega\sin 2(\theta+\tfrac{1}{2}\Omega)]. \quad (1)$$

But to find the velocity along the sides of the triangle we must consider the three rays which meet at the plate. From Huygens' principle $V_a/\sin i_a=V_{a'}/\sin i_{a'}=V_g/\sin r$ from which we derive $V_{a'}=V_a\sin i_{a'}/\sin i_a$. As shown by Lodge,[1] $i_{a'}=i_a+v^2/c^2\cos^2 i\sin 2\phi$, from which we derive for the reflected ray $V_{a'}=V_a[1+\frac{1}{2}v^2/c^2(1-\sin\Omega)\cot i\times\cos 2(\theta+\frac{1}{2}\Omega)]$, and finally

$$t=lv^2/c^3[(1-\sin\Omega)\cot i\cos 2(\theta+\tfrac{1}{2}\Omega)-\cos 2\theta+\sin\Omega\sin 2(\theta+\tfrac{1}{2}\Omega)]. \quad (2)$$

Since the obliquity is slight in the Michelson-Morley-Miller interferometer, being only $6\frac{1}{2}°$,

$$t=lv^2/c^3\cdot\sin\Omega\{[\sin 2\theta]_0^{\pi/4}+\sin 2(\theta+\tfrac{1}{2}\Omega)]_{(\pi/2)-\Omega}^{(3\pi/4)-\Omega}\}.$$

Disregarding the limits we have a perfect sine curve, but taking them into account the fringe shift curve has maxima and minima alternately $6\frac{1}{2}°$ and $83\frac{1}{2}°$ apart, which would lead to hit or miss results taking measurements every $22\frac{1}{2}°$, and this was found experimentally by Professor Miller.[2] With a 45° interferometer the maxima and minima would be 45° apart. It is evident that with the very oblique interferometer of Kennedy, only a very small part of the actual fringe shift would be found taking measurements every 90°, which accounts for the smallness of the results found by Illingworth.[3] Eq. (2), however, is believed to be only approximate, the exact solution being

$$\delta F=2l/\lambda\sin\Omega v^2/c^2\sin 2(\theta\pm\tfrac{1}{2}\Omega),$$

an equation which may be derived from the integrals of Lorentz, also by the method given in New York two years ago.[4]

[1] Sir Oliver Lodge, Phil. Trans. **184A**, 727 (1894).
[2] Dayton C. Miller, Rev. Mod. Phys. **5**, 203 (1933).
[3] K. K. Illingworth, Phys. Rev. **30**, 692 (1927).
[4] W. B. Cartmel, Phys. Rev. **49**, 647, 649 (1936).

SUPPLMENTARY PROGRAM

When two or more papers are offered by the same member one only of these will be assigned a place on the regular program while the others will be placed in a supplementary program to be called for if time permits.

Papers received after the program has been printed will be placed in the supplementary program.

The papers in the supplementary program may be called for only at the session indicated.

22. A Cloud-Chamber Study of the Alpha-Rays of Actino-Uranium. T. R. WILKINS AND D. P. CRAWFORD, *University of Rochester.*—W. M. Rayton and T. R. Wilkins[1] (1935) reported an analysis of the alpha-rays from a thinly evaporated film of metallic uranium in which complete resolution of the U I and U II isotopes was secured. In addition, there seemed to be evidence of a small group of alpha-rays, presumably due to actino-uranium, between the main peaks due to U I and U II. In the present work minor improvements have been made in the apparatus and a much larger number of tracks studied. The mean ranges check those reported (by R and W) for U I and U II (2.625 ± 0.0020 and 3.179 ± 0.0024). The main peaks are so well fitted by Gaussian curves that the residuum is unquestionably present. The mean range of actino-uranium appears to be nearer that of U II. The relative fewness of these tracks prevents high accuracy of range determination but it is felt that a mean air-range (15°C) of 2.99 cm will prove to be very close to the correct value. The determination of the relative activity is correspondingly uncertain. The number of tracks measured was 2140.

[1] Phys. Rev. **51**, 818–25 (1937).

SATURDAY MORNING AT 9:30 O'CLOCK

McLennan Laboratory, Room 43

Symposium of Invited Papers

1. **Monomolecular Films.** H. A. MCTAGGART, *University of Toronto.*
2. **High Speed Centrifuges and Some of Their Applications.** J. W. BEAMS, *University of Virginia.* (With demonstrations.)
3. **Superconductivity.** H. GRAYSON SMITH, *University of Toronto.*
4. **Magnetic Phenomena at Low Temperatures.** H. A. KRAMERS, *Leiden, Holland.*

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